

# RELAPSING FEVER IN THE GOLD COAST

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The following account of an outbreak of relapsing fever in Accra, Gold Coast Colony, has been considered worthy of record since the disease has never before been recognised in the Colony.

Doubts have been expressed as to the possibility of the disease having been prevalent in the Colony in former years. For it is well known that circumstances tend to render the recognition of the disease unusually difficult since attacks may be so mild in character as to resemble slight attacks of malaria. Examples of this nature were met with during the outbreak to be described, and the danger of spread resulting from the movements of persons suffering from the ambulatory type of spirillar fever was readily appreciated. It is difficult, however, to understand how the disease could have existed undetected for, as can easily be understood, routine blood examinations in all cases of fever can be numbered in their hundreds every year, and had a proportion of these unclassified fever patients been suffering from relapsing fever, the spirochete could scarcely have escaped detection.

In connection with this it should be stated that Simpson discovered spirochetes in a single blood smear out of a large number of blood smears examined in 1908, the year of an outbreak of plague in the Gold Coast Colony.

## EPIDEMIOLOGY

Two possible sources of infection present themselves in connection with the epidemic to be described hereafter. One of these appears to have been the soldiers who returned to the colony after hostilities had come to an end in what is now called Kenya Colony. It is recorded that the West African forces, especially those in the

Dar-es-Salaam area, suffered severely from relapsing fever. It is possible that a certain number remained infective subsequent to their return to the colony and that infection spread to their families and to neighbouring tribes.

This theory is supported to some extent by the fact that the majority of the returned troops were members of the Northern Territory tribes and that many of these took their discharge from the Headquarters of the West African Frontier Force at Coomassie. The theory gains further support from the large preponderance of Northern Territory tribesmen, some of whom had seen war service, amongst the patients encountered during the outbreak at Accra. Moreover, a report has recently come to hand from the Medical Authorities in the Northern Territories of the Colony, to the effect that six cases of relapsing fever (confirmed by blood examination) have been isolated from recruits to the West African Frontier Force.

There are, however, several excellent objections to the acceptance of this theory, not the least of which is the fact that the West African troops while in East Africa suffered from infection by *Sp. duttoni* carried by the *Ornithodoros moubata*, whereas the strain met with in the Accra epidemic resembled *Sp. obermeieri*, in this instance the vector being the body louse.

The other possible source of infection may have been the neighbouring French territory, since a very extensive epidemic of relapsing fever was reported from Senegal and French Niger Territory in 1921.

Epidemics of relapsing fever are said to be slow in onset and to show a gradually increasing mortality. In the outbreak under review the onset was certainly rapid though its rapidity is slightly obscured in the chart (No. 1) owing to the artificial conditions resulting from emergency legislation. The mortality, moreover, fortunately showed no gradual increase in severity, as seen by the fact that the case mortality rate for the first fifty cases was 6 per cent., while that for the remainder was less than 1 per cent.

#### INCIDENCE

##### (a) Sex

As in India and other countries where the disease is endemic the large majority of cases occurred in adult males, the actual figures being one hundred and fifty-six male cases (including two European cases) and only two female cases.

This very large preponderance of male cases is not dependent upon the degree of lousiness of the two sexes, for observations showed that infestation was shared in equal measure by both men and women. The explanation, rather, lies in the fact that the infected males belonged almost exclusively to an immigrant tribe, who had come into the Accra district from their Northern Territory villages in search of work and money to purchase European goods. It is contrary to the customs and habits of these tribesmen to bring their women and children with them, and as they return to their native villages as soon as they have been able to collect together a small quantity of trade goods, they do not possess property and housing accommodation in Accra. It is not difficult to understand the conditions under which these people live in Accra, crowded together in insanitary hovels lacking in light and air.

(b) *Age*

Since the majority of cases of relapsing fever occurred amongst males of Northern Territory tribes, it follows that most of the cases would occur in adults, since the journey to Accra from the Northern Territories is not a thing to be lightly undertaken by persons other than healthy adults. The age of the patients varied from 10 years in a Hausa boy to 55 in a Zabramah man. The patients were almost all illiterate and consequently their ages could only be estimated approximately—the average being between 25-30.

(c) *Race*

The following table gives the racial incidence.

TABLE I.

Race or Tribe	Number of Cases	Percentage
European ... ..	2*	1'2
Kroo ... ..	2†	1'2
Kotokoli ... ..	3	1'8
Hausa ... ..	3	1'8
Other Tribes ... ..	9‡	5'6
Zabramah (Zaberrima) ... ..	139	87'9
Total ... ..	158	99'5

\* A European who became infected in the course of experiments, and who became infected a second time at a later date, is included in this figure.

† Two volunteers who were infected in the course of experiments.

‡ Includes a volunteer who was infected in the course of experiments as in the other three cases.

The reasons for the preponderance of Zabramah and other Northern Territory tribesmen amongst the cases are not hard to seek. Reports of extensive epidemics of doubtful character are not infrequently received from the Northern Territories and one such, accompanied by heavy mortality and attributed to cerebro-spinal meningitis took place in 1920. It is possible that relapsing fever may have been the cause of certain of these outbreaks and that shortage of medical staff allowed it to remain unrecognised. In any case an undoubted epidemic of relapsing fever occurred amongst natives in French Territory bordering upon the Northern Territories in 1921, and intercommunication across the frontier would account for infection.

Once infected, the habits of these tribes would ensure a rapid spread and perpetuation of the infection. Owing to a great scarcity of water in most parts of the Northern Territories, except in the wet season, the average tribesman from this area is brought up from birth in the belief that water is intended for drinking and cooking purposes only. In consequence his body, clothes, bedding and living quarters are quite innocent of soap and water.

This condition of affairs contributes to a state of lousiness, and infestation with lice is so general (100 per cent. of the Northern Territory patients admitted to the Contagious Diseases Hospital, Accra, were found to be lousy on admission) that little, if any, attempt at disinfestation is made on the part of sufferers from lice. Coastal tribes in the Contagious Diseases Hospital were amazed at the Health Authorities interfering with what was considered a 'custom of the country' when disinfestation of admissions was carried out. The fact that Northern Territory tribesmen and Hausas sleep in their work-a-day garments tends to add to the degree of natural lousiness.

In this connection it is a remarkable fact that coastal tribes, not excepting the Kroos, are singularly free from lice, due, no doubt, to the fact that they do not share the aversion from washing their bodies and clothes exhibited by Northern Territory tribesmen. In order to obviate the possibility of the importation of plague, smallpox and other infectious and contagious diseases into the Colony, all Kroo immigrants from the Kroo coast are medically examined on arrival at this port. Nine hundred and thirty-one were

so examined in 1922, and although they had been in most cases crowded together on board ship and had not had facilities for washing their bodies and clothes for as long as three weeks in some cases, not a single one was found to be lousy.

A further reason for the large proportion of Northern Territory tribesmen among the cases of spirillar fever lies in the insanitary conditions in which they lived in Accra. Not possessing any house property or relatives with satisfactory living accommodation, they crowd together in insanitary corrugated-iron structures lacking light and ventilation, intended by their unscrupulous owners not as living quarters but as stores for building materials and the like.

Lastly, owing to a temporary trade depression many of the Zabramahs were unemployed for some time prior to the commencement of the outbreak and, having neither friends nor relations in the district, they became half starved. The synonym 'famine fever' indicates the traditional association of semi-starvation and relapsing fever. With their powers of resistance so diminished they afforded fertile soil for the germ of any infectious disease.

The number of cases occurring amongst other tribes was too small to warrant conclusions being drawn as to the comparative severity of the disease, but it can be stated with fairness that the more severe type of case—and in fact all the fatal cases—occurred amongst Zabramahs.

#### (d) *Case Distribution*

A map is appended showing the districts in which patients appeared to have been infected.

Neglecting the first case which occurred in a European who had passed through a considerable number of bush villages in the Accra District during the course of his work, a number of the earlier patients appeared from information obtained from them to have been infected either in their native villages in the Northern Territories, or in one of the towns or villages at which they rested at night time, during their journey to Accra. This bears out the theory that the epidemic in Accra and District originated directly in Northern Territory tribes.

It will be seen from the map that the vast majority of cases occurred in the Tudu and Zongo Rd. areas of Accra, in both of which the inhabitants are almost entirely members of Northern

TABLE II.

Table to show location of places where patients are presumed to have been infected.

Place	Number of Patients infected
Accra ... ..	130*
Some village in Accra bush or on the road from the Northern Territories to Accra ... ..	19†
Nsawam ... ..	6
Mangoase ... ..	3
	158

\* Includes three African patients accidentally infected in the Colonial Hospital, and three Africans and one European infected experimentally at the Medical Research Institute (the European suffered from two attacks).

† Includes one European case infected in some unknown village in the Accra bush.

TABLE III.

Table to show areas in which cases of relapsing fever occurred, but not necessarily where infection took place.

	Number of Cases
Accra, Block No. 11 ... ..	1
Accra, Block No. 12 ... ..	19
Accra, Block No. 13a ... ..	43
Accra, Block No. 15a ... ..	8
Accra, Block No. 15b ... ..	50
Accra, Block No. 16 ... ..	13
Accra, Block No. 17 ... ..	3
Accra, Medical Research Institute ... ..	4*
Accra, Native Hospital ... ..	3
Accra Bush ... ..	6†
Residence unknown ... ..	8
Total ... ..	158

\* These cases were infected experimentally.

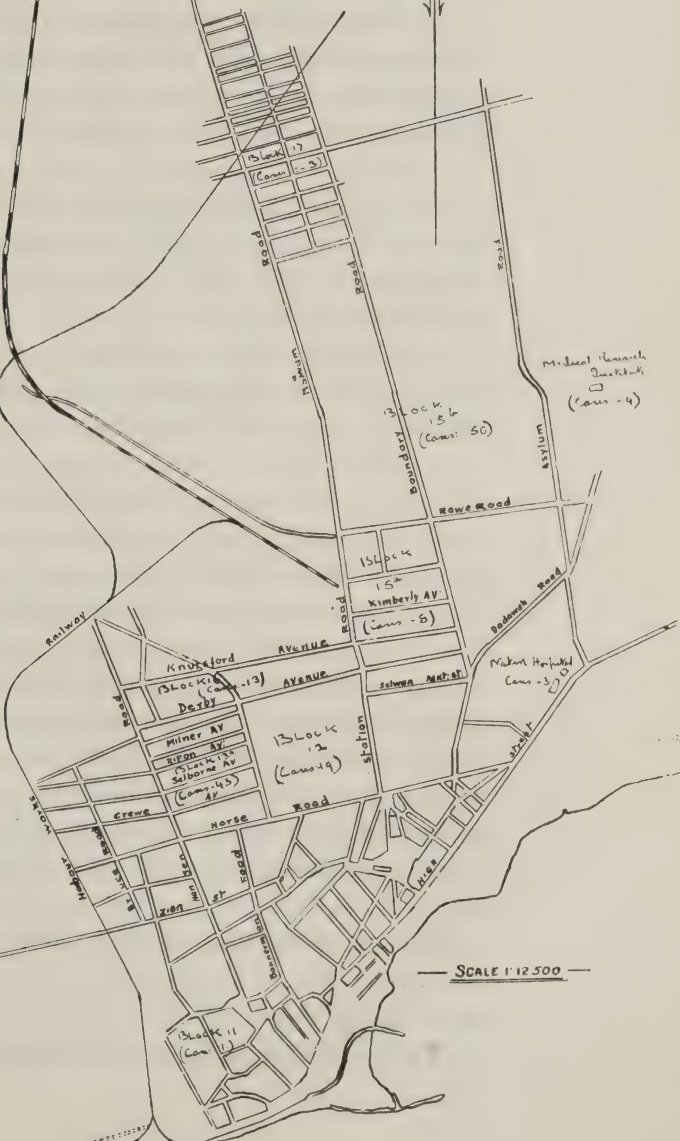
† This number includes a European, the first case to be discovered at the commencement of the epidemic.

— ACCRA —

TO SHOW WHERE CASES OF RELAPSING FEVER  
OCCURRED DURING THE EPIDEMIC —

— MARCH TO JULY 1923 —

Water works  
Railway



M. West Church  
Quakka  
(Case - 4)

Block 15  
Kimberly AV  
(Cases - 8)

Block 13  
Knutsford AV  
(Cases - 13)

Block 12  
Milner AV  
(Cases - 14)

Block 11  
Crewe Road  
(Case - 1)

SCALE 1" = 12,500'

Territory tribes or Hausas—both of whom live under unhealthy conditions.

Four cases are shown to have been infected during the course of experiments aiming at the discovery of the means of transmission of the spirionema, while three cases are shown as having been infected in the general wards of the Native Hospital, in which a number of relapsing fever patients were treated, prior to the declaration of the disease as an infectious disease necessitating removal to the Contagious Diseases Hospital.

It is noteworthy in connection with the distribution of cases that the areas from which they came were of a very low standard as regards housing accommodation, overcrowding in insanitary, ill-lighted and ill-ventilated hovels.

(e) *Mode of Transmission of the Disease*

During the initial stages of the Accra outbreak of spirillar fever preventive measures against the spread of the disease were greatly hampered by the lack of knowledge of the exact means of transmission of the organism.

*Ornithodoros moubata* Murray, the carrier of tick fever in the Congo, and *Ornithodoros savignyi* Aud, the possible carrier of relapsing fever in Somaliland, have not yet been recorded as occurring in the Gold Coast. *Ornithodoros talaje* Guérin-Méneville, the carrier of relapsing fever in Panama, was taken by Graham on *Cricetomys gambianus* (Report on Plague in the Gold Coast in 1908: W. J. Simpson, p. 22), it was also taken on *M. decumanus* during the small epidemic of plague in Accra in 1917, but its occurrence is so rare as to preclude its being the prevalent carrier of the present outbreak of relapsing fever. *Argas persicus* Oken is supposed by some inhabitants of the Gold Coast to be a common parasite of fowls in the Colony, but there is no authentic record of its occurrence; moreover, it has been shown by Edm. Sergent and H. Foley (1922) that this tick is not a carrier of North African relapsing fever, whereas *Pediculus humanus* is an efficient one.

Feeding experiments were carried out with bed bugs, mosquitoes, and lice.

*Bed bugs*

On the 14th April seven bed bugs collected from the clothes and



bedding belonging to cases of relapsing fever which had been interned in the Contagious Diseases Hospital, were placed on the shaven back of a small monkey. At least two of these bugs fed on the monkey, but it was difficult to keep them in position so that the experiment was abandoned within four hours of its commencement. The monkey during the following fortnight showed no symptoms of illness and spironemata were never found in its blood.

A second consignment of bugs from the same source numbering a dozen was placed on the arm of a native volunteer on the 15th April, a modification of Nuttall's pill-box method of feeding lice being adopted. The bugs were retained on the arm for three days and were then removed and dissected, no spironemata were found in them and the volunteer never showed any symptoms of relapsing fever.

On the 30th April twenty bugs which had been collected from the bedding of relapsing fever cases were kept alive in the incubator for four days and were then ground up in saline. The coarser particles having been removed, the emulsion, which contained no spironemata, was rubbed into the scarified skin of a volunteer; the volunteer never showed signs of relapsing fever and spironemata were not detected in his blood at any time during the two weeks following the inoculation.

#### *Mosquitoes.*

*Aedes argenteus* Poiret (*S. fasciata*) being probably the most universally distributed mosquito in West Africa, and being the recognised carrier of *Leptospira icteroides*, was selected for experiment. Eleven female *Aedes argenteus*, reared from larvae, were placed in a gauze-covered jar and fed upon the arm of a patient suffering from relapsing fever in the Contagious Diseases Hospital before the patient had received any treatment. Five of the mosquitoes were seen to be engorged with blood when they were brought back to the laboratory on the 13th April. The mosquitoes were separated into two lots; six mosquitoes, of which three had certainly sucked blood, were placed in one jar and five, of which two were engorged with blood, were placed in another jar, honey and water were placed in these jars and the mosquitoes were kept alive with occasional renewal of the honey until the 24th April. Two volunteers began to feed these mosquitoes on their arms on that date

—(one jar being assigned to each volunteer)—and continued to feed them daily till the 2nd May when the mosquitoes began to die. No spironema was found in any of the surviving mosquitoes on dissection and neither of the volunteers showed symptoms of relapsing fever during the fortnight following the abandonment of the experiment, and at no time were spironemata found in the blood of either of them.

*Lice. (Pediculus humanus).*

On the 14th April four lice (*Pediculus humanus*), collected from the clothing of a case of relapsing fever, were placed by the aid of the pill-box method on the back of a monkey, but they refused to suck blood and were therefore transferred to the arm of a native volunteer: on the 17th April these lice were all found to have died. They were at once ground up in saline and the emulsion was inoculated into a black rat. Neither the volunteer nor the black rat showed any signs of illness and no spironemata were at any time found in the blood of either.

On the 30th April twelve lice were placed on the arm of a native volunteer; these lice had been found in the clothing of contacts with relapsing fever cases, nine of the lice were found to be dead on the following morning. The three surviving were then placed on a case of relapsing fever in the Contagious Diseases Hospital; after sucking blood from this case they were brought back to the laboratory, kept in the incubator for forty-eight hours, and were then placed on the arm of a second volunteer who managed to keep them alive for three days. Neither of the volunteers suffered in the least degree during the two weeks succeeding the feeding of the lice and neither showed spironemata at any time in his blood. The nine lice from this batch which were found dead on the arm of the first volunteer on the 1st May were ground up in saline and the resulting emulsion injected subcutaneously into a monkey without any effect following, the monkey remained well and spironemata were never seen in its blood.

On the 14th May a dozen lice obtained from the clothing of a case of relapsing fever in the Contagious Diseases Hospital were placed on the arm of a native volunteer and left *in situ* for seventy-two hours. At the end of that time ten were found dead, the two survivors together with the ten dead were ground up in saline and

the emulsion inoculated subcutaneously into a monkey. Neither the volunteer nor the monkey developed symptoms and spironemata were not found in the blood of either during two weeks following the experiment.

On the 16th May twenty-five lice were received from the Medical Officer of Health who had collected them from the clothing of cases of relapsing fever. These lice were divided into two lots and fed on the arms of two volunteers for three days with the same result as in previous experiments—neither volunteer developing symptoms of relapsing fever or at any time showing spironemata in his blood.

The droppings from these lice adherent to the sides and bottom of the test tube in which they were received were gently washed out with saline and the mixture rubbed into the scarified arm of a volunteer, but he developed no symptoms and his blood remained free from spironemata for two weeks following the inoculation.

On the 26th May two dozen lice collected from the clothing of several cases of relapsing fever in the Contagious Diseases Hospital were received and were placed on the arm of one of us (A.I.) by the aid of the pill-box method; these lice were fed at intervals during the day and night till the 4th June when, there being only six survivors, they were ground up in saline and the emulsion which contained spironemata was inoculated into the scarified arms of two native volunteers. On the 12th June one of the volunteers complained of headache and lumbar pain, his temperature was found to be 100·2°F. and spironemata were found in thin and thick films of his blood. On the 13th June the other volunteer reported sick, his temperature was 100·6°F. and his blood showed spironemata. No spironemata were present in the blood of the individual upon whose arm these lice were placed at any time; it was examined from the 26th May to the 4th June whilst the lice were being fed.

On the 4th June four lice were supplied by the Medical Officer of Health (P.S.S-C.). These lice had been allowed to remain on a patient suffering from relapsing fever for five days after he had been treated with Novarsenobillon. When received at the laboratory the lice were placed on the arm of a native volunteer using the modified pill-box method; they were left on this individual's arm for twenty-four hours only and one of them had disappeared when the pill-box was removed. The three survivors were ground up in

saline and a portion of the emulsion was rubbed into the scarified arm of another volunteer, a second portion was dropped into the conjunctival sac of a monkey, while the residue was inoculated subcutaneously into a second monkey. This emulsion contained spironemata. Neither of the monkeys became ill and during the two weeks following the experiment no spironema was found in the blood of either. The second volunteer into whose arm the emulsion had been rubbed suffered from headache, and had a temperature of  $99.2^{\circ}\text{F}$ . on the 14th June, but no spironemata were found in thick films of his blood examined daily for a week after the slight rise of temperature. The first volunteer upon whose arm the four lice were placed began to be ill on the 15th June, but did not report himself as sick until the 18th June, when his temperature was found to be  $102^{\circ}\text{F}$ . and spironemata were numerous in thick films of his blood.

On the 11th June twenty lice from the clothing of cases of relapsing fever in the Contagious Diseases Hospital were supplied by the Medical Officer of Health (P.S.S-C.); these were at once placed on the arm of a native volunteer who fed them for three days. On the 14th June, however, as he seemed reluctant to continue to feed the lice, the survivors, five in number, were transferred to the arm of one of us (A.I.) where they were fed for another four days. During the last period of feeding two of the lice escaped one night from under the bandage retaining the pill-box in position and wandered freely over the body—judging from the number and position of the bites discovered the following morning. These lice were not recovered and may have been crushed in an attempt to allay the irritation of their bites. On the 18th June the feeding of the three ultimate survivors was discontinued and they were ground up in saline and the resulting emulsion, which contained spironemata, was inoculated subcutaneously into a monkey. This monkey showed no symptoms of illness and spironemata were not at any time found in its blood, which was examined daily till the 2nd July. The native volunteer who fed this batch of lice for three days immediately following their last meal of infective blood remained free from sickness, and no spironemata were found in his blood which was examined daily for twelve days after he had discontinued feeding the lice. The second individual who continued the feeding of the

lice became ill on the 25th June, his symptoms were headache and pains in the limbs and his temperature was  $101.6^{\circ}\text{F}$ ., but no spironemata were found in a thick film of blood; on the morning of the 26th June when the temperature was  $102.4^{\circ}\text{F}$ . a few spironemata were seen in a thick film of blood, they became more numerous at a later stage of the attack.

It may be of interest to mention that the individual who became sick as the result of this last feeding experiment was the same who developed relapsing fever as a result of accidental inoculation on the 28th March. It is possible that this second attack may have been a relapse of the former, but it appears to us more probably a reinfection, the interval between the recovery from the first attack and the onset of the second, a period of eleven weeks, being too great; besides at no time during the interval were any spironemata found in the blood which was repeatedly examined, and no symptoms of illness were experienced.

These feeding experiments appear to agree with the conclusions of the French observers in Tunis and Algeria, Ch. Nicolle, L. Blaziot et E. Conseil (1912), and Edm. Sergent et H. Foley (1922), namely, that the disease is not conveyed by the bites of lice or by their droppings being rubbed into excoriations of the skin, but that it is conveyed by the inoculation of crushed lice into wounds of the skin; further, that lice must be kept alive for about one week after feeding on a case of relapsing fever before they are capable of conveying the infection.

The two last experiments may seem rather equivocal, suggesting that the infection is conveyed by the bites of lice alone. It is to be noted, however, that in both experiments one or two lice escaped from the pill-box in which they were enclosed and wandered over the body generally; it is therefore quite possible that these stray lice were unconsciously crushed and rubbed into abrasions of the skin made in the process of scratching.

The pill-box method of feeding may not be an ideal method for use in the tropics, as pointed out by Cragg (1922), but when properly applied it certainly prevents crushing of its contents on the skin by any attempts at scratching.

Up to the time of writing, experiments have not been carried out to show whether infection is transmitted by infected lice to their

eggs, though this has been shown to be the case in other parts of the world.

It is noteworthy that lice were found on a very large proportion of all the patients treated at the Contagious Diseases Hospital, more especially among Zabramahs and other Northern Territory tribes and Hausas, in whom lice were found on the hair of the head, beard, axillae, pubic region and on wearing apparel.

The louse appeared to resemble the head and body louse found in Europe—*Pediculus humanus L.* It was remarked that lice tended to migrate from an individual having a high temperature, suggesting that the optimum skin temperature was probably in the neighbourhood of 98.4°F. or less. The temperature of the air and the relative humidity did not appear to influence the numbers or habits of the louse.

A graph and table given in the appendix illustrates the lack of influence exercised by temperature and humidity on the numbers of cases discovered in Accra from week to week.

(f) *Time of Occurrence of Cases*

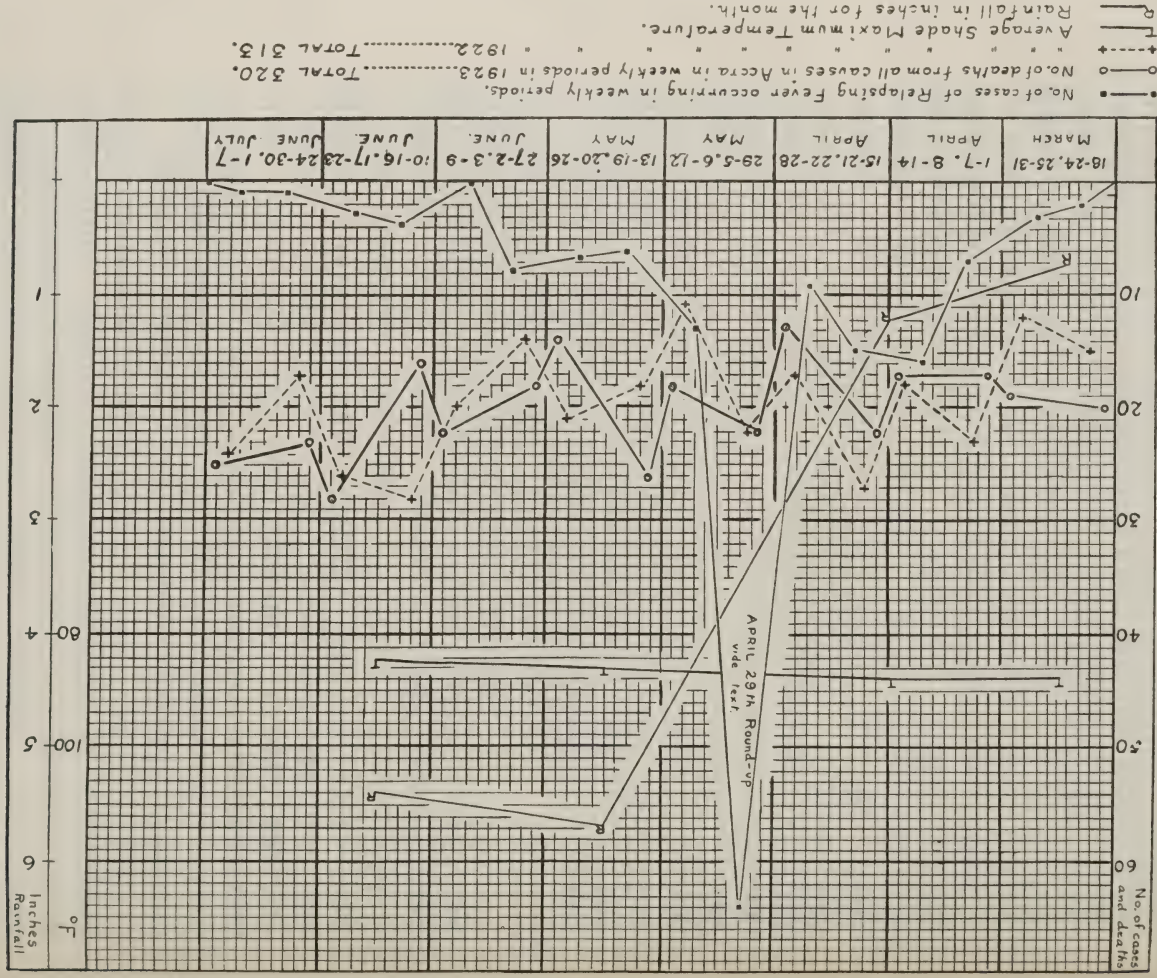
A chart is appended to show the progress of the epidemic from week to week. A somewhat erroneous impression is gained from an inspection of the chart, however, since the peak of the outbreak would appear to have occurred in the weekly period April 29th—May 5th. The large excess of cases occurring during this and the following weekly period resulted from legislation being passed on April 28th, which allowed the Health Authorities to round up nearly four hundred suspected cases and contacts with cases isolated from certain areas.

Briefly, a steady weekly increase in the number of cases reported occurred from the first case on March 18th, attaining a maximum during the weekly period April 29th—May 5th, and then steadily decreasing until only one case occurred during the weekly period June 24th—30th, this case being a second attack in a European infected experimentally in order to confirm the mode of transmission of infection.

(g) *Meteorological*

A daily maximum temperature of over 98.8°F. is stated to exert an unfavourable effect on lice. Conclusions based upon observations

CHART 1. ILLUSTRATING THE PROGRESS OF THE OUTBREAK OF RELAPSING FEVER IN ACCRA WEEK BY WEEK.



carried out over a period of three months showed that the small variations in atmospheric temperature and relative humidity had little or no influence on the degree of infestation of the Northern Territory tribes normally found infested with lice.

The outbreak commenced towards the end of the dry season during March, when the average maximum shade temperature was 88°F. and the relative humidity 67.

The greatest number of cases occurred at the end of April and at the commencement of May, during which times the rainy season had been in progress for a short time, and the average maximum shade temperature and relative humidity for April and May respectively being 88°F. and 86.5°F. and 67.1 and 76.9. The epidemic virtually came to an end early in July during the continuation of a rather more than normally wet season. The slight fall in temperature and the decided increase in rainfall between March and July appeared to have little influence on the course of the epidemic or upon the severity of individual cases.

(h) *Morphological Characters of the Spironemata*

The spironema found in the blood of cases met with in the present epidemic differs in no way from the descriptions given of the spironemata causing relapsing fevers in other parts of the world. Two hundred spironemata taken as they came—twenty-five in eight blood films from separate cases—were drawn with the help of the camera lucida and measured by the compass method, Macfie and York (1917). The shortest spironema found measured 10 $\mu$  and the longest 44 $\mu$ , the average length being 21.9 $\mu$ . The commonest lengths of the spironemata were 18 $\mu$  to 23 $\mu$ , and the average thickness of the spironemata was 0.3 $\mu$ . The pleomorphism noted by the French observers, J. Kerrest, A. Gambier et A. Bouron (1922), in the Soudan epidemic of relapsing fever has also been noticed by us, but it appears to us to be merely a passing phase; in blood films obtained from the same case on consecutive days, we have found few, if any, irregular forms on the first day, while on the second day ring and figure-of-eight forms have been numerous and did not require to be searched for. Breinl (1908) states with regard to *Sp. duttoni*, that coiled and complicated skein-like forms are most numerous in the blood of the internal organs just before the crisis sets in. Balfour and Bousfield (1911) have described and



figured these irregular forms of spironemata in relapsing fever at Khartoum. With the exceptions of ring, figure-of-eight and partially coiled forms, the shape of the organism did not appear to undergo any change in patients from day to day and, although the majority of the films examined were air-dried before being treated with Ruge's fluid, the exposure of blood films to hot air, to the vapours of formalin, to osmic acid, or to chloroform, appeared to have no influence on the shape of the organism.

The spironemata found in emulsions of crushed lice appeared to be shorter and more delicate than those seen in blood films, they also stained less deeply with gentian violet.

The number of organisms found in thick blood smears varied from over forty per field observed in a case which resembled in many respects a typical case of lobar pneumonia to as few as two over the greater part of the slide.

It would have been anticipated that spironemata would have been more numerous in severe cases of the disease and in first attacks than in relapses, but this was not invariably the case, although as a general rule they were less easy to find in relapsing cases and in fact were rarely found in what appeared to be a relapse after injection of a substerilising dose of Novarsenobillon. In one case spironemata were found by Dr. Mary Magill (who kindly assisted to examine a group of nearly two hundred films prepared from contacts and suspected cases) in a blood film of a contact who was not suffering from pyrexia at the time nor for the forty-eight hours intervening between his blood being taken and his treatment with Novarsenobillon. This case showed no signs or symptoms of illness and was discharged fourteen days subsequent to his receiving an intravenous injection of 0.3 gm. of Novarsenobillon, not having shown any signs of sickness. This blood film was one amongst twenty-five other films of contacts, all of whom appeared and were healthy; thus the possibility of the slides having become mixed could be excluded.

It is a remarkable fact that a careful search through blood films taken from some patients who appeared to be suffering from typical attacks of spirillar fever, who were stricken at the same time as their comrades, and who reacted to intravenous medication in exactly the same way as their fellow patients, failed to show the presence of infecting organisms.

In this connection it is noteworthy that in the severely collapsed cases with subnormal temperatures spironemata were not discovered in thick films until reaction had set in and the temperature mounted to 100°F. or more. Owing to the system adopted of taking the temperatures of all contacts and suspects and of carrying out a routine blood examination of every person segregated, whether he suffered from pyrexia or not, conclusive evidence was obtained as to the absence of the organism in the blood in the apyrexial state with the sole exception of the case described above. Spironemata were not found in the specimens of sputa and urine obtained from relapsing fever patients.

#### ANIMAL EXPERIMENTS

The following animals were inoculated with blood obtained from cases of relapsing fever at the Colonial Hospital or at the Contagious Diseases Hospital, Labadi:—White rats, black rats, *Cricetomys gambianus*, guinea-pigs, monkeys and one rabbit. The quantity of blood inoculated varied usually from 0.5 ccm. to 2 ccm., citrated blood being employed in all but one of the experiments. The rabbit and guinea-pigs proved refractory, no spironemata being at any time found in their blood, which was examined daily for a fortnight after inoculation. Eight white rats were inoculated at different times with infected blood, but in only one of them were spironemata seen; this rat was given 2 ccm. of blood from a human case on the 21st March and on the following day, twenty-six hours after the inoculation, two spironemata were found in a thin film of its blood; on no other occasion in this rat were spironemata found, although the blood was examined daily for a fortnight. That the blood employed in the cases of two of these white rats inoculated on the 28th March was infective was proved by the inoculator unwittingly infecting himself and developing relapsing fever, the first symptoms of which appeared on the 4th April—seven days after infection occurred.

Three monkeys were inoculated. Monkey No. 1 received a few drops of serum only, as the blood, obtained from the first case diagnosed, was carelessly allowed to clot in the syringe; this monkey never showed any symptoms and spironemata were never detected in its blood, which was examined daily for a fortnight after inoculation.

Monkey No. 2—a small baboon—was given 2 ccm. of citrated blood containing spironemata on the 21st March. On the 23rd it was not so lively as usual; on the 24th it had a temperature of 102° F. and spironemata were numerous in its blood; they were less on the 25th, and had disappeared completely on the 26th. From this day onwards to the 6th April, when the daily examination of the blood was discontinued, no spironemata were found. This monkey, which has been under close observation for three months, has never shown symptoms of a relapse.

Monkey No. 3—a sooty mangabey—was inoculated with about 2 ccm. of blood containing spironemata on the 23rd April. It appeared rather subdued on the 25th, but otherwise showed no symptoms of being ill, and its temperature was only 100° F.; on the 26th spironemata were numerous in its blood, but had disappeared on the 27th, and after this date no spironemata were found in its blood. This monkey has also been under close observation for nearly three months and has shown no signs of relapse.

Three black rats (*M. rattus*) were inoculated. Two received about 1.5 ccm. of citrated blood on the 28th March; this was the same sample of blood which failed to infect two white rats but proved infective in the case of the inoculator. Neither of these black rats showed spironemata in its blood, which was examined daily for twelve days following the inoculation. A third black rat was given 4 ccm. of citrated blood from a human case on the 2nd July. Spironemata were fairly numerous in its blood on the 4th, but were absent on the 5th, and have never been found since that date.

Two *Cricetomys gambianus* Waterhouse were given large doses (4 ccm.) of citrated blood which contained spironemata on the same occasion as the black rat last mentioned. On the 4th July spironemata were found in the blood of one of them; on the 5th both showed spironemata in large numbers in thick blood films; on the 6th the blood of the first rat which showed spironemata on the 4th July was free from them, while that of the other showed them in large numbers; subinoculations were made from each of these rats into another rat of the same species on this date. Both subinoculated rats showed spironemata, but at different dates after inoculation; the rat receiving blood containing spironemata showed them in its blood on the third day, the rat receiving blood which was apparently

free from spironemata on the eighth day. The original two rats relapsed, one after its blood had been negative for four days, the other after its blood had been negative for seven days.

A white rat was subinoculated with blood from Monkey No. 3 when it contained numerous spironemata on the 26th April, with a view to finding if passage through a monkey exalted the virulence of the strain for white rats. The blood of this rat never showed spironemata on any occasion, though examined daily for a fortnight after inoculation.

The results obtained from these inoculations appear to correspond closely with the inoculation experiments conducted by Gambier (1923) at Bamako. Gambier found monkeys to be readily infected with spironemata, white mice to be infected with difficulty, and rabbits and guinea-pigs to be refractory.

*Cricetomys gambianus*—the pouched rat—showed itself to be much more susceptible to infection with spironemata than any of the other animals employed; it was the only animal which appeared to relapse. It should be possible to convey the strain to Europe by means of a series of these rats provided they can be got to survive the rigours of a northern climate.

#### CLINICAL MANIFESTATIONS

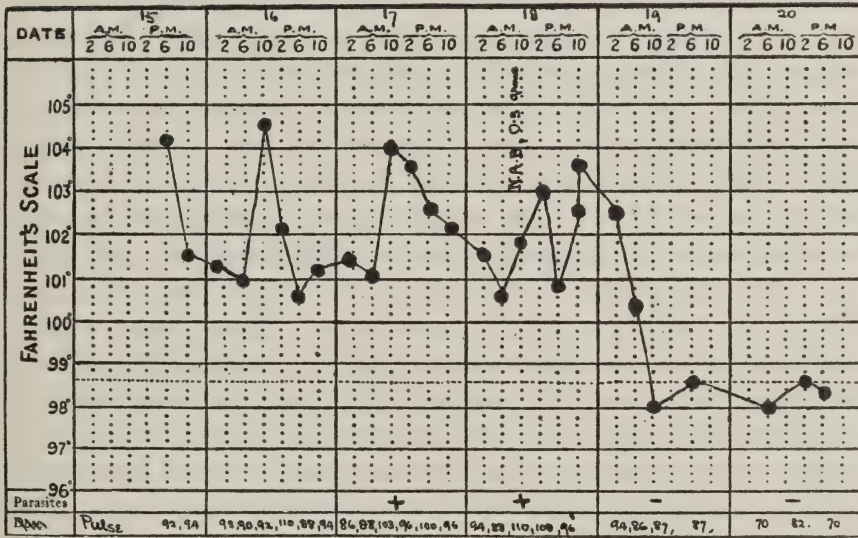
The first case recorded was I. A., an Italian contractor, aged 26. He was admitted to hospital on 15th March, 1923, with pyrexia, headache and severe prostration. He had been resident in the Gold Coast Colony two years, engaged in contracting work, and had enjoyed good health. He was taken ill on March 14th. His blood, on admission, was found free from parasites and pigment. It was examined again on March 17th, when it was found to contain numerous spironemata. On March 18th he was given 0.3 gm. Novarsenobillon intravenously. The following day, being the sixth day of the disease, the blood was found free from spironemata, and the temperature dropped to normal, where it remained until the patient's discharge from hospital on March 24th. There was no relapse, and six weeks later I. A. sailed for Italy, apparently in perfect health. The other symptoms in the case were icterus of the sclerae, severe pains, especially in the thighs, vomiting, enlargement

of the spleen, and a severe nephritis. The urine contained albumen and a heavy deposit of granular casts; all this cleared up by March 23rd.

The only other European case was accidentally infected on two occasions. His illness ran a similar course, excepting that jaundice and nephritis did not occur. In this case the rheumatic pains, especially in the thighs, were excruciating. The second attack was quite similar to the first, and occurred after an apyrexial period of three months. It was much milder in character. Both attacks were treated with the intravenous injections of 0.3 gm. Novarsenobillon, and there were no relapses.

I. A., Italian, Male, Age 26. Relapsing Fever. Admitted 15th March.

March, 1923



The clinical manifestation in natives presented a much more varied picture.

Owing to the necessity for the employment of one and sometimes two interpreters in the case of Northern Territory patients, it was far from being an easy task to obtain reliable information regarding symptoms.

The incubation period was not definitely established, but appeared to vary from seven days in the case of an accidental infection resulting from spirochetes in a drop of blood from a

patient, entering the system by way of a bruised nail bed, to twelve days in the case of another volunteer who allowed himself to be bitten by infected lice, and who is thought to have scratched a louse into his skin. In the case of two other volunteers, infection took place within eight or nine days of their receiving an emulsion of crushed lice rubbed into the scarified skin.

Prodromal symptoms were rare. The onset of the disease appeared to be sudden, and was often accompanied by a distinct rigor. Frontal headache became so marked in some cases as to warrant description by the patient as a pain like 'hammering on the temples.'

Some of the patients complained of severe pains in the cervical and lumbar regions, in thighs, shins and wrists. Prolonged attacks of shivering, rendering the taking of temperatures quite impossible, and very profuse sweating, were noticed in certain cases. Vomiting occurred in all but the mild cases, and persisted in some for two to three days after the fall in temperature, whether preceded by intravenous medication or not. The vomiting was at times bilious, but usually occurred after a drink of Akasa—a kind of pap—or after taking other food. The tongue was coated with white fur, and anorexia was marked during the course of the disease but gave place to a ravenous appetite in the majority of those who received an intravenous injection of Novarsenobillon. Thirst was severe, particularly, as would be expected, in those cases which suffered from frequent attacks of vomiting. The patients complained of giddiness when they attempted to stand; in some the gait was staggering, and others not only felt too giddy to stand in an erect posture, but collapsed when they even attempted to sit up. The asthenic condition persisted in some after convalescence had been established.

Both liver and spleen were enlarged in many cases, but as the patients for the most part came from malarial infected areas, it is possible that malaria was the cause of the splenomegaly, although diminution in size of the spleen was recorded during convalescence (quinine not being administered). Jaundice was present in remarkably few cases. In one series of one hundred and seventeen, only three patients suffered from jaundice.

The majority of the patients suffered from constipation, but a

certain number, particularly those in whom the temperature had fallen by crisis, suffered from diarrhoea.

The urine showed albuminuria during the pyrexial stages of the disease, but was not remarkable for any peculiarities. Oedema of face and hands, suggesting a nephritis, was seen in a small minority of cases.

Cough and a small degree of bronchitis were present in many of the cases, and in one pulmonary signs were so marked as to lead to a provisional diagnosis of pneumonia being made. Except in this case the pulse-respiration ratio was normal.

Mental symptoms were observed in a certain number of cases, and varied from a slight vacuity of mind and loss of memory to profound mental dulness and, in a small number, to active delirium and a comatose condition.

The pulse rates recorded were for the most part consistent with the height of the temperature in the pyrexial period, although in three cases out of a series of one hundred and seventeen in whom convalescence was prolonged owing to cardiac dilation, the rate remained unduly rapid for two weeks or more after the fall of temperature to normal. In the collapsed cases the pulse was of poor volume, thin and thready and often uncountable.

A somewhat unusual series of facts were noted in connection with the temperature recorded. It might have been assumed with all fairness that the severity of other signs and symptoms in a case of spirillar fever was proportionate to the height of the temperature. This was by no means the case. In some cases where the temperature rose to 104° F. or higher the symptoms were by no means severe, and recovery rapidly took place after suitable treatment. In other cases where the temperature did not rise much higher than 100° F. other signs and symptoms were grave. In the single case under the care of one of us (P.S.S-C.) which ended fatally the temperature on admission was 99° F. A thick blood smear was taken and large numbers of spironemata were observed. The patient was given an intravenous injection of 0.6 gm. Novarsenobillon and then put to bed. His temperature rose to 101° F. by 6 p.m. the same evening. On the following morning his temperature had fallen to 99° F., but his condition was grave and he could not be persuaded to take any fluid nourishment. A blood smear was negative to spironemata.

He vomited bilious-looking material twice during the day, and by 6 p.m. his temperature was  $99.4^{\circ}$  F. When seen on the following morning at 6-30 a.m.—probably the fourth day of his illness—he was found to be comatose. The thermometer did not register any temperature and his radial pulse was so small in volume and rapid in frequency as to be almost imperceptible and quite uncountable. A blood smear was negative to spironemata. Efforts were made to combat the condition by raising the end of his bed, by applying hot blankets, hot water bottles and by administering intravenous and subcutaneous salines and brandy. By 10-30 a.m. his temperature had risen to  $97.2^{\circ}$  F. and his pulse, though rapid (120), was of good volume and tension. Respirations which had been of the Cheyne-Stokes variety at 6-30 a.m. were now comparatively normal although the breathing was stertorous. By 2-30 p.m. the patient's temperature had risen to  $101^{\circ}$  F. His pulse was of good volume and tension and about 120. Breathing had become markedly stertorous and respirations numbered 36 to the minute. A blood smear was taken but no organisms were found. The patient died at 4 p.m. on the same day, having remained unconscious for over 48 hours. As far as could be gathered, the patient had been ill for two days prior to his admission to hospital, thus death took place within five days of the initial symptoms. The above case has been given at some length in order to show that the height of the temperature had little relation to the severity of an attack. It is to be noted that the blood smears taken on the second and third days of the illness prior to the patient receiving Novarsenobillon showed a very heavy infection of spironemata.

Another type of temperature was seen in the case of a female subject of good physique and aged 20. The temperature recorded on the first four days of her illness was  $100^{\circ}$  F. or less. A blood smear taken on the first day proved on examination to show a moderate number of spironemata. On the second day—the patient remaining without treatment—the number of organisms in a thick film was very small, and on the third day none were found. By the fifth day the temperature had fallen to  $97.4^{\circ}$  F., and it remained low for ten days. On the tenth day following the initial fall to below normal, the temperature rose to  $100^{\circ}$  F. On the following morning at 6-30 a.m. the temperature was  $104.4^{\circ}$  F. Spironemata were not



found in the blood until the eleventh day following the original commencement of the apyrexial period after the first attack. Owing to the obvious suffering of the patient and to her serious condition, one of us (P.S.S.-C.) did not feel justified in withholding Novarsenobillon any longer and gave 0.6 gm. intravenously at 11 a.m. By 6-30 p.m. the temperature had fallen to 103° F. On the following morning the temperature still stood at 100° F. but fell to 99° F. the same evening and to 97° F. by the next morning. Spironemata were found in moderate numbers at the height of the relapse but not subsequent to the treatment with Novarsenobillon.

In a second patient—an adult male aged 44—untreated until the first relapse, the temperature on admission on the third day of his illness was 103.2° F. Spironemata were present in moderate numbers in a thick blood smear. The patient received no treatment other than a cold sponging, and his temperature fell the day after his admission to 97° F., remained normal or subnormal for two days and then rose to 101° F. During the apyrexial period, organisms were absent from blood smears, but were present on the day of the relapse. The patient appeared to be suffering considerably during the relapse, and it was not considered fair to him to withhold specific treatment any longer. The temperature fell to normal and spironemata disappeared from blood smears within twenty-four hours of the patient being injected with 0.6 gm. Novarsenobillon and no further relapse occurred.

Particulars of a fourth case are worthy of record since the patient appeared to be suffering from pneumonia on admission. The patient was admitted to hospital on the second day of the disease. His temperature, pulse and respiration at 2-45 p.m. on the day of admission were respectively 103.6° F., 100, and 40. Although a well nourished male of 25 he was too weak to move hand or foot and was delirious. Bronchitic râles were heard over both sides of his chest and signs of early pneumonic consolidation were heard over the left lower lobe. A blood smear showed the presence of spironemata in large numbers. The patient was very jaundiced. He was given 0.6 gm. of Novarsenobillon intravenously and his temperature, which rose to 104° F. by 6 p.m. the same evening, fell to 100° F. on the following day and then to 97° F. on the morning of the third day after his admission. Subsequently, the temperature rose again on

the evening of the third day following admission to  $99.8^{\circ}$  F. and to  $100^{\circ}$  F. on the morning of the fourth day, but fell to normal on the same day. From thence onwards the temperature went to a few points above normal for the next fourteen days and then steadied down to subnormal. The pneumonic signs cleared up without any signs of resolution, but the patient suffered from bronchitis for a fortnight following his admission to hospital. Spironemata were not found in the patient's blood subsequent to the treatment with Novarsenobillon.

When discussing the variations in temperature in cases of relapsing fever it would be unwise to take the four cases quoted above as typical examples. By far the majority of cases suffered from temperature varying from  $100^{\circ}$  F. to  $105^{\circ}$  F., though a small number showed spironemata in blood smears with a temperature of only  $99^{\circ}$  F. In most cases a fall of temperature to normal or subnormal took place within twelve hours of treatment with Novarsenobillon, although in some cases the temperature remained above normal though lower for two to three days and then fell. During the early days of the epidemic when only 0.3 gm. of Novarsenobillon was administered, a number of the patients relapsed after varying intervals. In a small minority of cases it was found necessary to give 0.6 gm. of the drug followed by 0.3 gm. after an interval of three days.

#### RELAPSE

The information regarding the occurrence of relapses is scanty for two reasons. Africans, and in this they resemble all races, do not take kindly to hospital treatment, and purely medical cases prefer to remain in their own homes rather than to enter hospital, however comfortless the former may be, and however much their chances of recovery may be so impaired. It follows naturally that if, owing to pressure having been brought to bear on them, they have been admitted to hospital for treatment, their one aim and object is to obtain their discharge therefrom as soon as possible. Consequently, when a case of relapsing fever was admitted to hospital, endeavours were made to sterilise the patient as regards the infecting organisms in his blood and to effect his cure with the least possible delay. By making his stay in hospital as short as was compatible

with his own well-being and with the safety of the general public, other cases occurring in the town were encouraged to seek medical attention as soon as they became infected, instead of remaining concealed from the health authorities and so helping to spread infection.

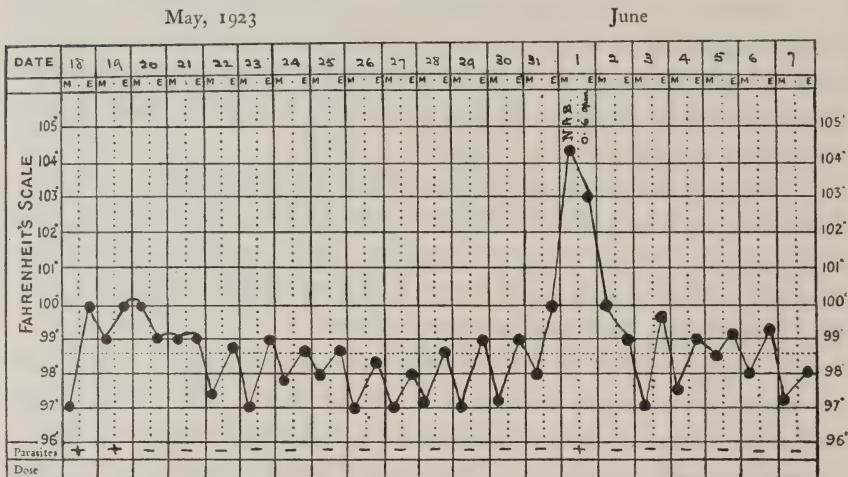
Secondly, it was not considered justifiable, except in a very small number of cases, to withhold treatment from a patient with a view to determining the approximate length of the apyrexial period between attacks, since by so doing, the well-being and possibly even the life of the patient was placed in jeopardy.

The relapses observed can be divided into two classes, one in which the patient had received no specific treatment, but only general symptomatic treatment as, for example, light diet, saline purge, cold sponging, and the second class in which specific treatment with Novarsenobillon had been administered.

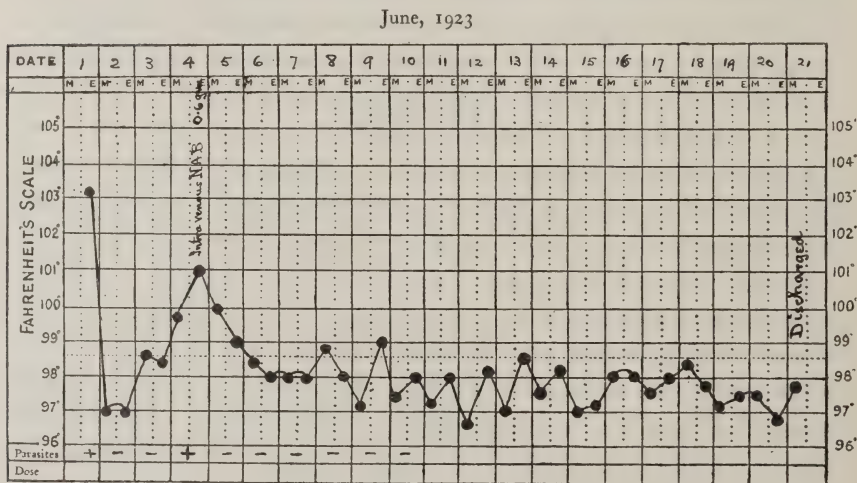
Examples of the first were afforded by the cases of a man and woman. The man was admitted on the third day of his illness suffering from the usual symptoms of relapsing fever and with a temperature of  $103.2^{\circ}\text{F}$ . Spironemata were present in moderate numbers in a thick blood film. The patient received symptomatic treatment only and his temperature fell to  $97^{\circ}\text{F}$ . on the day following admission and remained normal or subnormal for two days. On the third day following the crisis which terminated the first attack, the temperature rose to  $101^{\circ}\text{F}$ ., and spironemata which had been absent from blood films during the apyrexial period of two days were again found in blood films. The condition of the patient did not justify the withholding of treatment further. The woman suffered severely from headache, pains in the back, legs and wrists, but her temperature during the first four days of her illness did not exceed  $100^{\circ}\text{F}$ ., although a blood film taken on the first day showed a moderate infection with spironemata. The number of spironemata seen on the second day of the disease was smaller, while none were found on the third and fourth days. On the fifth day of the disease the temperature fell to  $94.4^{\circ}\text{F}$ . and remained low for ten days. On the tenth day following the initial fall to below normal the temperature rose to  $100^{\circ}\text{F}$ . and on the following morning at 6-30 a.m. to  $104.4^{\circ}\text{F}$ . Spironemata were found in moderate numbers, but the patient's condition was sufficiently serious to make further delay in the administration of specific intravenous medication quite unjustifiable.

Several examples of the second series of relapses, that is to say, relapses occurring in spite of treatment, occurred amongst the cases

ARMAH, Female, Age 20. Relapsing Fever. Admitted May 18th.



SEIDU SYIE, Male, Age 44. Relapsing Fever. Admitted June 1st.



treated in the Contagious Diseases Hospital. The following case is remarkable for its severity and for the unduly long period that elapsed between the patient's apparent cure and his relapse. The



On the following morning his temperature was  $102.6^{\circ}$  F. but a blood film failed to show the presence of spironemata. His temperature on the following day was  $105^{\circ}$  F., spironemata were present in a blood film, and he was given 0.3 gm. Novarsenobillon intravenously. By the evening of the same day the patient's temperature had fallen to  $103^{\circ}$  F. The next morning the temperature had still further fallen to  $99.6^{\circ}$  F., and by the evening to  $98.4^{\circ}$  F. For the 3rd to the 9th of May inclusive the temperatures were  $96^{\circ}$ ,  $99^{\circ}$ ,  $98.4^{\circ}$ ,  $98.6^{\circ}$ ,  $99.2^{\circ}$  F., but no spironemata could be found in blood films taken during this period. Thereafter the temperature remained normal or subnormal until the 21st of May when the patient was discharged. Three days later on the 24th of May (fourteen days after the patient's temperature had fallen to normal) the patient complained of anorexia, diarrhoea and frontal headache. He was seen on the 26th of May and found to have a temperature of  $100^{\circ}$  F., and spironemata were observed in his blood film. On this occasion he was given 0.6 gm. of Novarsenobillon. His temperature rose to  $102^{\circ}$  F. by 6 p.m. the same night, but had fallen to  $99^{\circ}$  F. at 6 a.m. on the following morning. Organisms, however, were still visible in blood films. The temperature fell to  $97.4^{\circ}$  F. the same evening and subsequently remained normal or subnormal until the 13th June when he was discharged, his temperature not having been raised for sixteen days. The interesting point about this case is that the original pyrexial period lasted for about eleven days, followed by an apyrexial period of about fourteen days, when a relapse occurred. The pyrexial period during the relapse lasted for four days and was followed by a period of apyrexia for sixteen days. The explanation in this case is that the 0.3 gm. of Novarsenobillon administered was too small a dose to sterilise, but that it probably had the effect of retarding the relapse which took place fourteen days after the patient's temperature had been normal or subnormal. During the relapse, spironemata were present in large numbers in blood films until the third day of the disease, when a 0.6 gm. dose Novarsenobillon was given. Organisms were present in small numbers on the morning following the injection, but disappeared from blood films taken thereafter. Several similar cases occurred in which an initial dose of 0.3 gm. of Novarsenobillon appeared to effect a cure, but in which it ultimately proved to be insufficient in preventing the occurrence of a relapse.

A few patients relapsed even after receiving 0.6 gm. of the drug, but for routine work, dealing with a large group of persons, this dose appeared to be satisfactory, followed by 0.3 gm. or 0.6 gm. in the small number of cases failing to react to the initial dose, or showing signs of relapse.

Briefly, in untreated cases relapses occurred with an apyrexial period varying from two to ten days, while in treated or partially treated cases the apyrexial period varied from two to fourteen days. As a rule, but not invariably, the relapse was less severe both in signs and symptoms and also in duration than the initial attack. Out of the hundred and seventeen cases that came under the care of one of us (P. S. S-C.) twenty-three, or 19 per cent., relapsed on one occasion, and eight, or 6.8 per cent., relapsed a second time. Thus the total number of relapses in the one hundred and seventeen patients was thirty-one, or 26.5 per cent., of all the patients.

The following table shows the results :—

TABLE IV.

	Blood film		Unknown	Total
	Positive	Negative		
First Relapse ... ..	11	7	5	23
Second Relapse ... ..	3	5	...	8
Totals ... ..	14	12	5	31

In cases where the organisms could not be found in blood films, the diagnosis of relapse was based upon rise of temperature and the recurrence of the signs and symptoms of the original attack.

### IMMUNITY

*Second Attacks.* Immunity is said to be of short duration in relapsing fever. It would be unfair to draw any such conclusions from the epidemic under review, since so little time has elapsed since the occurrence of the cases described above. One undoubted second attack occurred, however. The patient, a European, originally became accidentally infected with relapsing fever while injecting

infected blood into a rat. Seven days later he developed the signs and symptoms of the disease. At first no spironemata were seen in his blood, but after two days of moderately severe pyrexia the organism was found to be present in small numbers. The patient was treated with 0.3 gm. Novarsenobillon intravenously, and rapidly recovered. This first attack occurred in the beginning of April. At the end of June the same individual contracted a severe attack of the disease as the result of feeding infected lice on his forearms—two escaped and are thought to have been scratched into his skin. The second attack was rather less severe than the first, but reacted to treatment with Novarsenobillon as rapidly as had been the case in the first attack. If the patient acquired any immunity from the first attack, and this is probable, since he subsequently carried out a series of experiments, feeding on his forearms lice from relapsing fever patients, the immunity was of decidedly short duration, in fact less than eleven weeks.

#### TREATMENT

Apart from intravenous medication with Novarsenobillon given intravenously in 10 c.c. of warm, sterile, distilled water in doses varying from 0.3 gm. in the early cases to 0.6 and 0.9 or 1.2 gm. (divided into two to three doses) in the later cases, the treatment administered to patients was symptomatic. Patients were washed, shaved and disinfested on admission, and put to bed with a sleeping mat and two warm blankets. They received their injection of Novarsenobillon as far as possible on a fasting stomach. If they wished, they were given two biscuits and a drink of milk a short time after the injection. Cold sponging was resorted to where the temperature was 103° F. or higher, but otherwise, apart from being given as much water in small quantities as they wished, the patients were left to sleep quietly until the following morning, care being taken to avoid chills in cases where the temperature fell by crisis. The following morning a saline purge was administered, and if conditions were satisfactory and no vomiting was present a light diet was given. It was noticed that the patients not only wanted to get up and resume their usual everyday life immediately after the fall of temperature had occurred, but that they wished to resume a normal diet at once. As a rule the attack left the patients somewhat weak,

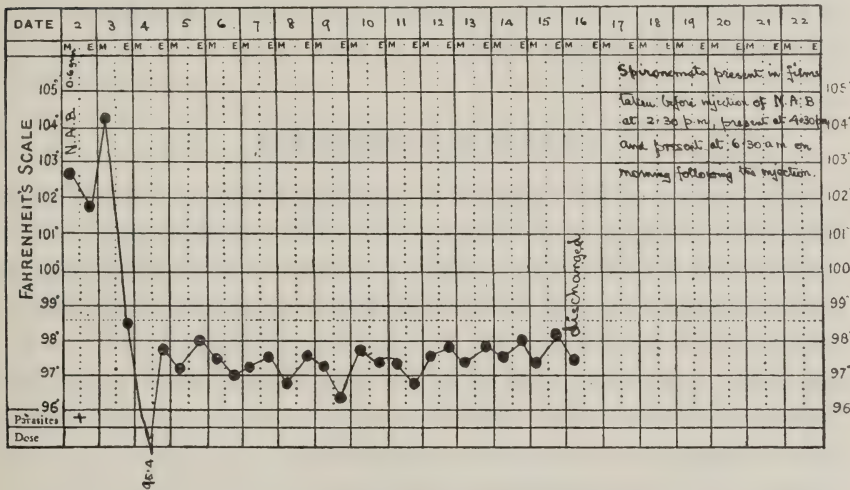


and vomiting immediately occurred, if the patients were allowed to satisfy their ravenous hunger. In those patients who reacted well to the treatment and in whom no elevation of temperature occurred within the fourteen days subsequent to the fall of temperature to normal, attempts were made as far as possible to graduate both diet and exercise until, for some days before the patients were due for discharge, they had resumed a normal life.

In order to obviate the possibility of relapses, patients were kept in hospital until their temperatures had been normal for fourteen days. Blood smears were taken of all patients with temperatures

BUKARI, Male, Age 38. Relapsing Fever. Admitted July 2nd.

July, 1923



Typical moderately severe case showing fall of temperature by crisis 24 hours after administration of 0.6 gm. Novarsenobillon.

above 99° F., and even if spirochetes were not found in the blood films and other conditions could be excluded, further treatment with Novarsenobillon was carried out. This step appeared to be justified in the light of the subsequent histories of such cases. Among the one hundred and seventeen patients admitted to the Contagious Diseases Hospital, eighteen had already received an intravenous injection of 0.6 gm. Novarsenobillon. Injections—three of which were given intramuscularly owing to the inability to discover a vein of adequate size—to the number of one hundred and

thirty were given by one of us (P. S. S-C.). Of the total number of injections one hundred were of 0.3 gm. and forty-eight of 0.6 gm. Patients who received but one injection numbered one hundred and seventeen, those who received two numbered twenty-three, while eight patients had to receive a third injection. Generally speaking, apart from a little vomiting for two or three days after the injection (this vomiting occurred in untreated cases and consequently may have borne no relation to the intravenous medication) no ill-effects were experienced from the use of Novarsenobillon. One death occurred in a series of one hundred and seventeen cases that came under the notice of one of us (P. S. S-C.), but the patient was in a serious condition prior to the injection, and when death occurred on the third day following the injection, it could be attributed with fairness to the disease. West Africans appear to tolerate organic arsenical preparations exceedingly well.

#### PREVENTIVE MEASURES

The control of the outbreak of relapsing fever in Accra during the earlier stages was hampered by two considerations, viz., ignorance of the vector and mode of transmission of the particular strain of organism and lack of legal powers to deal with cases, suspects and contacts. The vector being unknown, lice, ticks, bed bugs, mosquitoes and biting flies were all treated as suspect. Samples of all these were collected either, as in the case of the first two from patients known to be suffering from the disease or, as in the case of the remainder, from bedding, mats and other articles in infected premises, and were taken to the Medical Research Institute.

Measures were taken against all possible vectors, and with this end in view attention was concentrated on premises situated in congested areas of the town occupied by Hausas and members of Northern Territory tribes, whose habits in regard to overcrowding and a marked aversion from cleanliness, adequate lighting and ventilation were well known. Careful house-to-house visits were made in those areas and throughout the town, as many as 46,013 being carried out during March, April, May and June, one of us (P. S. S-C.) being responsible for 1,006. During these inspections personal, domestic and general cleanliness was preached, all old

sacking, lousy bedding and other refuse being removed from compounds. Moreover, efforts were made to see that all houses were provided with adequate lighting and ventilation. During these visits a practice was made of urging any person who appeared to be ill and suffering from fever to go for treatment to the Native Hospital.

The procedure adopted early in the epidemic when a case of relapsing fever was reported was for the patient to be admitted into the Native Hospital, for his quarters to be disinfected and disinfested and for a watch to be kept on all contacts, any of whom showing signs of fever being urged to report to the Medical Officer at the Native Hospital.

By the fourth week of the outbreak it was evident that infection which appeared to have been introduced into Accra from bush villages was spreading to other parts of the town from houses already infected with relapsing fever. To obviate this tendency to spread, it was strongly urged that legislation should be passed, in order that the Health Authorities might round-up all persons suffering or suspected to be suffering from relapsing fever, together with contacts with such cases, for the purpose of segregating them and sterilising them as far as concerned the presence of spirochetes in their blood. Legislation was not passed, however, until the 28th of April, by which time the disease had appeared in several parts of the town, though principally in Tudu and the Zongo. On the 29th of April, acting within the powers obtained through this legislation, it was possible to effect a round-up of cases, suspects and contacts on a much larger scale, so that within twenty-four hours of legislation being passed, over three hundred and sixty-three patients, suspects and contacts were removed from infected premises to the Contagious Diseases Hospital. Where necessary, one or two contacts were allowed to remain in such infected premises, to safeguard the property from thieves, to keep the premises clean and to care for any horses or other animals. Such persons were visited daily to exclude the possibility of their having contracted the disease.

The health of the person permitting, a routine was adopted at the Contagious Diseases Hospital in almost every case. On admission all male cases, suspects and contacts had their heads,

armpits, beards and pubic hair shaved, while in the case of females the hair was close clipped and shaved from their armpits and pubes under the supervision of a female sanitary inspector. Subsequently the shaving was followed, where physical conditions permitted, by a sea bath and by a wash-down where a sea bath was inadvisable. All clothing was shed into barrels containing a 5 per cent. solution of IZAL prior to the bath being taken, and after the bath a warm blanket, sleeping mat, and cup and plates were issued to everyone. Temperatures and blood smears were then taken and recorded and the groups dealt with were allotted accommodation in three classes of huts, according as to whether they were thought to be suffering from relapsing fever or were merely suspects, or contacts with cases and suspects. Special diet, as for example, milk, tea, broths, etc., was given to patients, whilst the remainder received two meals per day. Hot Akasa was given in the early morning as soon as temperatures had been taken, and was followed at mid-day by a large meal of rice, plantain, fula or other foodstuffs purchased in the markets. As far as possible the tastes and wishes of patients and contacts were consulted with regard to the variety of food supplied. Contacts were detained for fourteen days, during which time they were given a certain amount of work to do in the way of scrubbing out huts, keeping the segregation compounds clean, helping with the chopping-up of firewood, with the preparation of food and drawing of water. They enjoyed sea baths daily, arrangements being made for the opposite sexes to bathe at different times. At the end of the quarantine period, if their temperatures which were taken morning and evening had remained normal, the contacts were again submitted to a thorough shaving, and were given a bath, and then had their disinfected and disinfested clothing returned to them and thereafter were discharged. Contacts or suspects who developed raised temperatures, or in whom blood films proved to be positive as regards the presence of spirochetes, were immediately transferred to the huts reserved for patients. After receiving appropriate medication, patients were kept in hospital until they had been free from pyrexia for fourteen days—blood films being taken daily while temperatures were raised.

It is noteworthy that the following method of disinfecting and disinfesting clothes and blankets appeared to give the best results.

The articles to be disinfested were first soaked for forty-eight hours in barrels containing 5 per cent. solution of Izal. They were then washed and placed in the sun during the middle of the day on sheets of corrugated iron. This resulted in most efficient disinfestation, for the heat generated was at least 150° F. Neither lice nor eggs capable of hatching survived this treatment. Purses and amulets, the latter carried in great numbers by Hausas and Northern Territory tribesmen, required special treatment.

In order to minimise the risk of infection being carried from the hospital to Accra, the auxiliary staff of the hospital were persuaded to stay in special quarters reserved for them in the grounds of the hospital, and all the staff, including one of us (P. S. S-C.), took further precautions by frequent baths and by shaving the hair from axillae and pubes. A police guard was maintained at the hospital during the period of the outbreak, and the Non-Commissioned Officer in charge is to be congratulated in not losing a single patient or contact.

#### CONCLUSIONS

1. This first recorded outbreak of relapsing fever in British West Africa is due to a spirochete conveyed by lice.
2. As regards inoculation experiments, monkeys, black and white rats become infected with the strain, but do not relapse; guinea-pigs and rabbits are refractory, whilst the pouched rat becomes infected and relapses.
3. The vectors of the organism in the present epidemic and the inoculation experiments suggest that the parasite is not the *Sp. duttoni*, but corresponds more closely to *Sp. recurrentis* (vel *obermeieri*), or a related strain.
4. Novarsenobillon is a specific in the treatment of the disease.
5. Immunity does not appear to be lasting or complete in cases treated with Novarsenobillon.

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